



Advanced Pedestrian/Bicycle Crash Analysis



Instructors: Tony Becker & Mike Reade

Date: 27-Aug-14

Place: EVOC Track, Pierre, South Dakota



Number of Tests: 9 tests

Test Surface: Rough chip seal with loose pebbles on top of surface

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Additional training required to fully understand the technical analysis.



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Place: EVOC Track, Pierre, South Dakota

Vehicle One:

2006 Dodge Durango

OL: 201.3 in

OW: 76.0 in

WB: 118.2 in

FOH: 38.6 in

ROH: 44.5 in

Weight: 5188.0 lb

Hood H: 42.0 in

Searle (Angle):

$$V = \frac{\sqrt{2 \times \mu \times g \times d}}{[\cos \theta + (\mu \times \sin \theta)]}$$

Searle Maximim:

$$V_{\max} = \sqrt{2 \times \mu \times g \times d}$$

Searle (Mass & Carry):

$$V_{\min} = \frac{M + m}{M} \sqrt{\frac{2\mu g(d - \text{Carry})}{1 + \mu^2}}$$

Searle Minimum:

$$V_{\min} = \sqrt{\frac{2 \times \mu \times g \times d}{1 + \mu^2}}$$

Crash Data:	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
Ped Ht (ft):	5.42	5.42	5.42	5.42	5.42	5.42	5.42	5.42	5.42	N/A
Ped C/M Ht (ft):	3.33	3.29	3.25	3.25	3.00	3.58	3.33	3.21	3.33	N/A
Ped Slide D (ft):	98.00	30.57	31.70	50.25	64.25	50.50	66.50	51.70	41.75	N/A
Airborne D (ft):	0.00	34.68	30.40	39.00	51.50	44.25	35.50	69.80	54.00	N/A
Ped f-Value:	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.79	N/A
Throw D (ft):	98.00	65.25	62.10	89.25	115.75	94.75	102.00	121.50	95.75	N/A
Takeoff (Min):	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	N/A
Takeoff (Max.):	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	N/A
1st Evid. (ft):	42.00	17.67	32.91	18.80	20.50	N/A	20.10	12.00	N/A	N/A
Ped Weight (lb):	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	N/A
Vehicle Data:										
Hood Height (ft):	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	N/A
C/M - Hood Change (ft):	-0.17	-0.21	-0.25	-0.25	-0.50	0.08	-0.17	-0.29	-0.17	N/A
Braking (Yes=Y/No=N):	N	Y	Y	Y	Y	Y	Y	N	N	N/A
Skid Total (ft):	59.00	76.00	71.00	96.00	118.00	114.00	89.00	120.00	137.00	N/A
Skid to Impact (ft):	N/A	38.75	33.25	27.75	37.70	17.00	17.50	N/A	N/A	N/A
Road f-Value:	0.54	0.66	0.69	0.66	0.66	0.59	0.69	0.63	0.51	N/A
Impact Spd (mph):	31.70	28.16	28.31	37.94	42.23	43.79	40.00	47.40	46.60	N/A
Radar (Start Braking):	32.00	27.00	23.00	33.00	37.00	N/A	33.00	48.00	49.00	N/A
Radar (Impact):	32.00	27.00	23.00	33.00	37.00	N/A	33.00	48.00	49.00	N/A

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Advanced Pedestrian/Bicycle Crash Analysis



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Test 1



Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	34.22 mph
Searle (20 Degree) Takeoff:	33.26 mph
Searle Minimum Formula:	33.17 mph
Searle Maximum Formula:	36.37 mph

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	5,418.00 lb
Pedestrian Weight: (m)	36 lb
Ped C/M Height: (H)	3.33 feet

Vehicle Speed Analysis:

Vehicle Speed - Start of Braking:	31.70 mph
Vehicle Speed - Impact:	31.70 mph
Radar Speed - Start of Braking:	32.00 mph
Radar Speed - Impact:	32.00 mph
IMPACT SPEED To Be Used:	31.70 mph

Searle Minimum Analysis: (1993, 2009)

$$V_{\min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

$$= 32.91 \text{ mph}$$

Other Calculations:

Speed (With Adjusted Data):	34.55 mph
Throw Minus Carry Distance:	88.40 feet
Location of First Evidence:	42.0 feet
% of Speed Attained (Ped):	105%
Difference (C/M vs. Hood H):	-0.2 feet
Takeoff From Video (Degrees):	0 Degrees
Carry Distance:	9.60 feet

Searle Minimum Analysis: (2009)

$$V_{\min} = \frac{M + m}{M} \sqrt{\frac{2\mu g(d - \text{Carry})}{1 + \mu^2}}$$

$$= 31.71 \text{ mph}$$

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

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Test 2



Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	27.92 mph
Searle (20 Degree) Takeoff:	27.14 mph
Searle Minimum Formula:	27.07 mph
Searle Maximum Formula:	29.68 mph

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	5,418.00 lb
Pedestrian Weight: (m)	36 lb
Ped C/M Height: (H)	3.29 feet

Vehicle Speed Analysis:

Vehicle Speed - Start of Braking:	39.50 mph
Vehicle Speed - Impact:	28.16 mph
Radar Speed - Start of Braking:	27.00 mph
Radar Speed - Impact:	27.00 mph
IMPACT SPEED To Be Used:	28.16 mph

Searle Minimum Analysis: (1993, 2009)

$$V_{\min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

$$= 26.76 \text{ mph}$$

Other Calculations:

Speed (With Adjusted Data):	27.57 mph
Throw Minus Carry Distance:	61.75 feet
Location of First Evidence:	17.7 feet
% of Speed Attained (Ped):	96%
Difference (C/M vs. Hood H):	-0.2 feet
Takeoff From Video (Degrees):	7 Degrees
Carry Distance:	3.50 feet

Searle Minimum Analysis: (2009)

$$V_{\min} = \frac{M + m}{M} \sqrt{\frac{2\mu g(d - \text{Carry})}{1 + \mu^2}}$$

$$= 26.50 \text{ mph}$$

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)



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Test 3



Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	27.24 mph
Searle (20 Degree) Takeoff:	26.48 mph
Searle Minimum Formula:	26.40 mph
Searle Maximum Formula:	28.95 mph

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	5,418.00 lb
Pedestrian Weight: (m)	36 lb
Ped C/M Height: (H)	3.25 feet

Vehicle Speed Analysis:

Vehicle Speed - Start of Braking:	38.60 mph
Vehicle Speed - Impact:	28.31 mph
Radar Speed - Start of Braking:	23.00 mph
Radar Speed - Impact:	23.00 mph
IMPACT SPEED To Be Used:	28.31 mph

Searle Minimum Analysis: (1993, 2009)

$$V_{\min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

$$= 26.09 \text{ mph}$$

Other Calculations:

Speed (With Adjusted Data):	26.86 mph
Throw Minus Carry Distance:	56.60 feet
Location of First Evidence:	32.9 feet
% of Speed Attained (Ped):	93%
Difference (C/M vs. Hood H):	-0.3 feet
Takeoff From Video (Degrees):	4 Degrees
Carry Distance:	5.50 feet

Searle Minimum Analysis: (2009)

$$V_{\min} = \frac{M + m}{M} \sqrt{\frac{2\mu g(d - \text{Carry})}{1 + \mu^2}}$$

$$= 25.38 \text{ mph}$$

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

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Test 4

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Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	32.66 mph
Searle (20 Degree) Takeoff:	31.74 mph
Searle Minimum Formula:	31.65 mph
Searle Maximum Formula:	34.71 mph

Vehicle Speed Analysis:

VC Speed - Start of Braking:	44.60 mph
VC Speed - Impact:	37.94 mph
Radar Speed - Start of Braking:	33.00 mph
Radar Speed - Impact:	33.00 mph
IMPACT SPEED To Be Used:	37.94 mph

Other Calculations:

Speed (With Adjusted Data):	32.79 mph
Throw Minus Carry Distance:	79.65 feet
Location of First Evidence:	18.8 feet
% of Speed Attained (Ped):	83%
Difference (C/M vs. Hood H):	-0.3 feet
Takeoff From Video (Degrees):	0 Degrees
Carry Distance:	9.60 feet

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	5,418.00 lb
Pedestrian Weight: (m)	36 lb
Ped C/M Height: (H)	3.25 feet

Searle Minimum Analysis: (1993, 2009)

$$V_{\min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

$$= 31.39 \text{ mph}$$

Searle Minimum Analysis: (2009)

$$V_{\min} = \frac{M + m}{M} \sqrt{\frac{2\mu g(d - \text{Carry})}{1 + \mu^2}}$$

$$= 30.10 \text{ mph}$$

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)



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Test 5



Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	37.19 mph
Searle (20 Degree) Takeoff:	36.15 mph
Searle Minimum Formula:	36.05 mph
Searle Maximum Formula:	39.53 mph

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	5,418.00 lb
Pedestrian Weight: (m)	36 lb
Ped C/M Height: (H)	3.00 feet

Vehicle Speed Analysis:

Vehicle Speed - Start of Braking:	50.30 mph
Vehicle Speed - Impact:	42.23 mph
Radar Speed - Start of Braking:	37.00 mph
Radar Speed - Impact:	37.00 mph
IMPACT SPEED To Be Used:	42.23 mph

Searle Minimum Analysis: (1993, 2009)

$$V_{\min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

$$= 35.84 \text{ mph}$$

Other Calculations:

Speed (With Adjusted Data):	37.29 mph
Throw Minus Carry Distance:	107.65 feet
Location of First Evidence:	20.5 feet
% of Speed Attained (Ped):	85%
Difference (C/M vs. Hood H):	-0.5 feet
Takeoff From Video (Degrees):	3 Degrees
Carry Distance:	8.10 feet

Searle Minimum Analysis: (2009)

$$V_{\min} = \frac{M + m}{M} \sqrt{\frac{2\mu g(d - \text{Carry})}{1 + \mu^2}}$$

$$= 35.00 \text{ mph}$$

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

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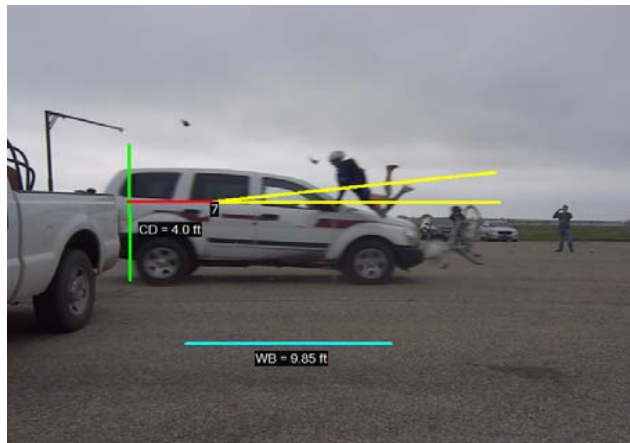


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Test 6



Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	33.65 mph
Searle (20 Degree) Takeoff:	32.70 mph
Searle Minimum Formula:	32.61 mph
Searle Maximum Formula:	35.76 mph

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	5,418.00 lb
Pedestrian Weight: (m)	36 lb
Ped C/M Height: (H)	3.58 feet

Vehicle Speed Analysis:

VC Speed - Start of Braking:	47.10 mph
VC Speed - Impact:	43.79 mph
Radar Speed - Start of Braking:	N/A mph
Radar Speed - Impact:	N/A mph
IMPACT SPEED To Be Used:	43.79 mph

Searle Minimum Analysis: (1993, 2009)

$$V_{\min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

$$= 32.34 \text{ mph}$$

Other Calculations:

Speed (With Adjusted Data):	33.42 mph
Throw Minus Carry Distance:	90.75 feet
Location of First Evidence:	N/A feet
% of Speed Attained (Ped):	74%
Difference (C/M vs. Hood H):	0.1 feet
Takeoff From Video (Degrees):	7 Degrees
Carry Distance:	4.00 feet

Searle Minimum Analysis: (2009)

$$V_{\min} = \frac{M + m}{M} \sqrt{\frac{2\mu g(d - \text{Carry})}{1 + \mu^2}}$$

$$= 32.13 \text{ mph}$$

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

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Advanced Pedestrian/Bicycle Crash Analysis



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Test 7



Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	34.91 mph
Searle (20 Degree) Takeoff:	33.93 mph
Searle Minimum Formula:	33.84 mph
Searle Maximum Formula:	37.11 mph

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	5,418.00 lb
Pedestrian Weight: (m)	36 lb
Ped C/M Height: (H)	3.33 feet

Vehicle Speed Analysis:

VC Speed - Start of Braking:	44.30 mph
VC Speed - Impact:	40.00 mph
Radar Speed - Start of Braking:	33.00 mph
Radar Speed - Impact:	33.00 mph
IMPACT SPEED To Be Used:	40.00 mph

Searle Minimum Analysis: (1993, 2009)

$$V_{\min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

$$= 33.59 \text{ mph}$$

Other Calculations:

Speed (With Adjusted Data):	36.19 mph
Throw Minus Carry Distance:	97.00 feet
Location of First Evidence:	20.1 feet
% of Speed Attained (Ped):	85%
Difference (C/M vs. Hood H):	-0.2 feet
Takeoff From Video (Degrees):	0 Degrees
Carry Distance:	5.00 feet

Searle Minimum Analysis: (2009)

$$V_{\min} = \frac{M + m}{M} \sqrt{\frac{2\mu g(d - \text{Carry})}{1 + \mu^2}}$$

$$= 33.22 \text{ mph}$$

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

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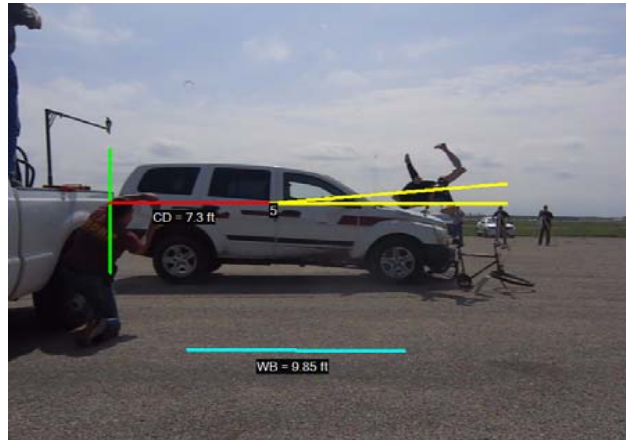


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Test 8



Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	38.10 mph
Searle (20 Degree) Takeoff:	37.03 mph
Searle Minimum Formula:	36.93 mph
Searle Maximum Formula:	40.50 mph

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	5,418.00 lb
Pedestrian Weight: (m)	36 lb
Ped C/M Height: (H)	3.21 feet

Vehicle Speed Analysis:

VC Speed - Start of Braking:	47.40 mph
VC Speed - Impact:	47.40 mph
Radar Speed - Start of Braking:	48.00 mph
Radar Speed - Impact:	48.00 mph
IMPACT SPEED To Be Used:	47.40 mph

Searle Minimum Analysis: (1993, 2009)

$$V_{\min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

$$= 36.71 \text{ mph}$$

Other Calculations:

Speed (With Adjusted Data):	37.92 mph
Throw Minus Carry Distance:	114.20 feet
Location of First Evidence:	12.0 feet
% of Speed Attained (Ped):	78%
Difference (C/M vs. Hood H):	-0.3 feet
Takeoff From Video (Degrees):	5 Degrees
Carry Distance:	7.30 feet

Searle Minimum Analysis: (2009)

$$V_{\min} = \frac{M + m}{M} \sqrt{\frac{2\mu g(d - \text{Carry})}{1 + \mu^2}}$$

$$= 36.04 \text{ mph}$$

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

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Test 9



Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	42.46 mph
Searle (20 Degree) Takeoff:	39.37 mph
Searle Minimum Formula:	37.38 mph
Searle Maximum Formula:	47.64 mph

Vehicle Speed Analysis:

VC Speed - Start of Braking:	46.60 mph
VC Speed - Impact:	46.60 mph
Radar Speed - Start of Braking:	49.00 mph
Radar Speed - Impact:	49.00 mph
IMPACT SPEED To Be Used:	46.60 mph

Other Calculations:

Speed (With Adjusted Data):	44.30 mph
Throw Minus Carry Distance:	91.75 feet
Location of First Evidence:	N/A feet
% of Speed Attained (Ped):	80%
Difference (C/M vs. Hood H):	-0.2 feet
Takeoff From Video (Degrees):	4 Degrees
Carry Distance:	4.00 feet

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	5,418.00 lb
Pedestrian Weight: (m)	36 lb
Ped C/M Height: (H)	3.33 feet

Searle Minimum Analysis: (1993, 2009)

$$V_{\min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

$$= 36.86 \text{ mph}$$

Searle Minimum Analysis: (2009)

$$V_{\min} = \frac{M + m}{M} \sqrt{\frac{2\mu g(d - \text{Carry})}{1 + \mu^2}}$$

$$= 36.83 \text{ mph}$$

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

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